REMARKS/ARGUMENTS

Claims 34-66 are pending in the present application. Claims 59-66 have been withdrawn. In view of the Examiner's earlier restriction requirement, Applicants retain the right to present Claims 59-66 in a divisional application. Claims 34-58 have been rejected. In the present Amendment, Claims 34, 43-45, 49-52, and 54-58 have been amended, claims 35-42, 46-48, and 53 have been cancelled, and claims 67-76 have been added.

OBJECTIONS

The Examiner has objected to the drawings under 37 C.F.R. § 1.83(a). The Examiner states that the non-thermal plasma reactor with a mixed type of dielectric barrier structural carrier must be shown or the feature canceled from the claims. Applicant notes that in accordance with the present invention, a "mixed" type of dielectric barrier structural carrier element may be prepared from numerous combinations of the double, single, or null dielectric barrier structural carriers. For example, a stack of two elements is illustrated in FIG. 8. The stack shown in FIG. 8 is constructed by combining a C-shaped single dielectric barrier structural carrier and a null dielectric barrier structural carrier thereby providing a "mixed" type of element formed from a single and a null dielectric barrier structural carrier. FIG. 5A has been added to further illustrate a "mixed" type dielectric barrier structural carrier element comprising a single dielectric barrier structural carrier element prepared with a double dielectric barrier structural carrier and a null dielectric barrier structural carrier.

REJECTIONS UNDER 35 U.S.C. §112

The Examiner has rejected claims 40, 42, 47 and 48 under 35 U.S. C. 112, first paragraph, stating that the specification is not enabling for a non-thermal plasma reactor with mixed types of dielectric barrier structural carriers. Applicants submit that the specification is enabling for a non-thermal plasma reactor having an element or elements constructed from "mixed" types of dielectric barrier structural carriers as well as from pairs of same type dielectric barrier structural carriers. The present invention provides a structural carrier non-thermal plasma reactor element (or stack of elements) comprising one or a combination of structural carriers arranged to form the element or elements.

The structural carriers comprise null dielectric barrier structural carriers, single dielectric barrier structural carriers, and double dielectric barrier structural carriers. The null dielectric barrier structural carriers comprise a structural carrier for providing structural support; a first electrode layer disposed upon a first side of the structural carrier; and a second electrode layer disposed upon a second side of the structural carrier. The single dielectric barrier structural carriers comprise a structural carrier for providing structural support; a first electrode layer disposed upon a first side of the structural carrier; a second electrode layer disposed upon a second side of the structural carrier; and a first thin high k dielectric barrier layer disposed upon the first electrode layer for providing dielectric barrier function. Double dielectric barrier structural carriers comprise a structural carrier for providing structural support; a first electrode layer disposed upon a first side of the structural carrier; a second electrode layer disposed upon a second side of the structural carrier; a first thin high k dielectric barrier layer disposed upon the first electrode layer for providing dielectric barrier function; and a second thin high k dielectric barrier layer disposed upon the second electrode layer for providing dielectric barrier function. Various reactor elements are contemplated with the structural

carrier elements being constructed from one or a combination of the three main types of structural carriers (null, single, and double dielectric barrier structural carrier).

For example, as discussed above, FIG. 8 shows a "mixed" type element in accordance with the present invention whereby a single dielectric barrier structural carrier element is constructed from a C-shaped double dielectric barrier structural carrier and a C-shaped null dielectric barrier structural carrier. FIG. 5A has been added to illustrate yet another possible embodiment of a "mixed" type element comprising a single dielectric barrier structural carrier element prepared with a double dielectric barrier structural carrier plate and a null dielectric barrier structural carrier plate.

Claims 40, 42, 47 and 48 have been cancelled hereby and claims 34, 43-45, 49-52, 54-58 have been amended for clarification purposes and to make explicit this aspect of the invention that was implicit or inherent in the claims as originally presented. Claims 35-42, 46-48, and 53 have been cancelled. Claims 67-76 directed to various embodiments wherein the present structural conductor elements are constructed from combinations of null, single, and double dielectric barrier structural carriers have been added. No new matter has been introduced.

REJECTIONS UNDER 35 U.S.C. §102

The Examiner has rejected claims 34-37, 49, 52, and 53 under 35 USC § 102(b) as being anticipated by U.S. Patent 5,417,936 to Suzuki et al. (hereinafter "Suzuki") in light of U.S. Patent 6,119,455 to Hammer et al. (hereinafter "Hammer"). Claims 34, 49, and 50 have been rejected under 35 USC §102 (b) as being anticipated by U.S. Patent 2,744,865 to Penning (hereinafter "Penning"). Reconsideration is respectfully requested of these rejections based upon the following considerations.

Present Invention and Its Advantages

The present invention provides a non-thermal plasma reactor element including a structural carrier having a thin conductive layer disposed upon the structural carrier. A thin high dielectric constant ("high k") barrier layer is disposed upon the conductive layer. In this way, structural support function is substantially provided by the structural carrier and dielectric barrier function is substantially provided by the high k barrier layer. The present invention includes separating previously combined functions and accomplishes improved NOx conversion by specialization of structural carriers, electrodes, and dielectric barriers. Double dielectric, single dielectric, and null dielectric barrier elements are constructed from combinations of one or more double, single, and null dielectric barrier structural carriers that are arranged to form an element or a stack of elements. Conductive layers and high k barriers layer are tailored to have dimensions as thin as possible for the particular NTP reactor application. Using a thin (about 0.02 mm thick) conductive layer that can withstand current flow extremes, it is possible to reduce the stress between the conductive layer and the structural carrier for good durability in extreme temperature environments at minimum cost. By reducing the high k dielectric barrier to the minimum level that can withstand dielectric breakdown (for example, about 0.25 mm thick for alumina), reactor capacitance increases, and reactor size is minimized at low cost. Advantageously, since the structural carrier of the present invention need not provide dielectric barrier function, optimum utilization of conventional extrusion materials is enabled without respect to permittivity (dielectric constant). The structural carrier dielectric can be optimized for low cost, fabricability, mechanical and thermal properties. For example, cordierite, having a low dielectric constant of 5.3, may be used as a structural carrier material due to the excellent thermal shock capability of cordierite. As the present reactor capacitance is not dependent on the thickness of the structural carrier, structural carrier thickness may be determined based upon the mechanical

strength and durability requirements of a given system. The present invention advantageously provides a low-cost structural support enabling tailoring of the conductor and high k barrier layers for optimal electrical performance--i.e., the present invention enables conductor and high k barrier layers to be tailored as thin as possible for the particular application. The present invention advantageously provides a highly practical design providing high capacitance and thus high performance capability. See, for example, the instant application at pages 6-7.

Distinctions Over Suzuki and Hammer

In contrast to the present invention, which is directed to a non-thermal plasma reactor for taking NOx rich exhaust gas and reducing the NOx levels as a result of the plasma formed in the non-thermal plasma reactor, Suzuki discloses a plate-type ozone generator. The plate-type ozone generator of Suzuki has a discharge cell including a box-shaped casing formed by using a dielectric of a quartz containing silicon dioxide. (See Abstract of Suzuki.) The ozone generator of Suzuki includes a discharge cell 1 having a box-shaped casing formed by using a dielectric of a quartz containing silicon dioxide having a purity of not less than 99.9%. The inside of the casing defines a discharging gap 2 of the cell 1. The cell 1 also has a high-voltage electrode 3 and an earthed electrode 4, each electrode being provided by forming an electrically conductive coating on one of an opposite pair of outer surfaces of the casing. A plurality of partition walls 5, made of quartz, are disposed in the discharging gap 2 so as to define a flow passage through which a material gas can flow. A material gas inlet pipe 6 and an ozone outlet pipe 7, capable of communicating with the discharging gap 2, are provided on the same side of the discharge cell 1 as the earthed electrode 4. (See Suzuki at Column 3, lines 1-20 and FIGS. 1 and 3). As shown in FIG. 4, each pipe 6 or 7 has a quartz tube 61 or 71 fixed to the discharge cell 1, and a stainless tube S joined to the quartz tube by a fused joint

comprising a cover glass tube CP and a cover alloy tube CA. The ozone generator further includes a heat sink 8 contacting the high-voltage electrode 3, and a cooling chamber 9 contacting the earthed electrode 4.

Suzuki is not directed to non-thermal plasma devices and does not teach or suggest a structural carrier element for a non-thermal plasma reactor. FIGS. 1 and 3 of Suzuki do not show a structural carrier element. In Suzuki, the quartz dielectric barriers substantially support the element, thus requiring the quartz to be thick. This is in direct contrast to the concept of the present invention, which employs a less expensive structural carrier to substantially provide the support function thereby conserving the amount of more expensive dielectric material required (the present high k barrier layer).

Further, the ozone generator as disclosed in Suzuki would not function for plasma treatment of NOx exhaust emissions. The ozone generator of Suzuki includes a looped end of the plasma region. When the quartz is charged, the charge will spread along the quartz before forming plasma. The looped regions are connected and would lead to dramatic electrical efficiency losses with the design taught in Suzuki as well as loss of a majority of plasma formation due to shorting across the loops. If the loops were extended to minimize this effect, the result would be additional untreated area with the ozone generator. Even if one were to employ the ozone generator of Suzuki as a non-thermal plasma treatment device for NOx emissions, the plate-like design as taught is fundamentally flawed and cannot be constructed to efficiently treat exhaust gas. In order to create optimal NOx treatment, plasma gaps should be about 1 millimeter. To treat a sufficient volume of exhaust gas, twenty cells would typically be required. The generator of Suzuki is essentially limited to a two-cell design.

Suzuki does not teach or suggest all of the elements of the present structural carrier non-thermal plasma reactor element. Therefore, Suzuki does not form the proper basic for an anticipation rejection.

Hammer discloses a process and device for purifying exhaust gases containing nitrogen oxides whereby the polluted exhaust gas flows through a reactor volume to which non-thermal discharges are applied, while being brought into contact with a solid reducing agent (preferably, carbon fibers) at least once, and preferably several times. The device includes means (disks) for field enhancement substantially periodically spaced in the reactor. See Hammer Abstract and Column 3, lines 1-6. While Hammer does discuss a type of non-thermal plasma discharge, Hammer does not teach or suggest structural carrier non-thermal plasma reactor elements. Hammer cannot, therefore, form the proper basic for an anticipation rejection.

Distinctions Over Penning

Penning discloses an ozone generator wherein the drier 12 and the generator 10 are mounted upon studs secured to a plate 18 which is made of insulating material. Each generating plate comprises two similar halves 30 of substantially rectangular phenolic sheet material rounded from one side at the edges thereof and enclosing a thin foil 32 of electrical conducing material. The sheets 30 are substantially larger than the foil 32 contained therein so that the sheets extend beyond the foil at all edges. See Penning at Column 2, lines 1-32.

Penning discloses an ozone generator employing foil disposed between dielectric sheets to create a <u>dielectric</u> supported ozone generating element. Penning does not disclose structural carrier non-thermal plasma reactor elements. Penning cannot, therefore, form the proper basic for an anticipation rejection.

<u>REJECTIONS UNDER 35 U.S.C. §103</u>

Claims 54 and 55 have been rejected under 35 USC § 103(a) as being unpatentable over Suzuki in view of Hammer and further in view of U.S. Patent

5,411,713 to Iwanaga (hereinafter "Iwanaga"). Claim 56 has been rejected under 35 USC § 103(a) as being unpatentable over Suzuki in light of Hammer. Claims 57 and 58 have been rejected under 35 USC § 103(a) as being unpatentable over Suzuki in view of Hammer and further in view of U.S. Patent 6,106,788 to Rau et al. (hereinafter "Rau"). Reconsideration is respectfully requested of these rejections based upon the following considerations.

Distinctions Over Suzuki in view of Hammer and further in view of Iwanaga

The cooling plates as taught in Iwanaga are not structural carriers as presently disclosed and claimed. Iwanaga discloses an ozone generating apparatus for generating ozone which is used in various processes such as semiconductor production processes, deodoration of various waste gases, industrial and medical treatments, cleaning, sterilization and or decoloration of drinking water, running water or sewage. See Iwanaga at Column 1, lines 1-15. The ozone generating apparatus has an ozonizing chamber which defines a passage for gases leading from an inlet for a material gas to an outlet of product gas. The material gas is ozonized while flowing through the ozonizing chamber by the effects of ozonizing discharge electrodes which are arranged in stages along the flow of the gas and which are supplied with different levels of voltage such that the electrode which is on the downstream side as viewed in the direction of flow of the gas is supplied with higher voltage than upstream electrode. See Iwanaga at Column 1, lines 57-68. The apparatus includes a plurality of ozone generating units 5a, 5b, and 5c which are connected in series through communication pipes 6 so as to form a plurality of ozonizing stages. Each ozone generating unit has an ozone generating chamber 3 provided with a material gas inlet 1 and a product gas outlet 2 and ozonizer discharge electrodes 4 disposed therein. Each ozonizer discharge electrode has a linear form as illustrated and is disposed to oppose a tabular induction electrode 10 across a dielectric

plate 8. The ozone generating units 5a, 5b, and 5c are stacked one on another with double-sided cooling plates 11 interposed between respective two adjacent units 5a, 5b, 5c, with top and bottom of the stack being connected by single-sided cooling plates 12. Preferably, the cooling plates 11, 12 are made from alumite aluminum coated with a corrosion resistant layer of aluminum oxide. The tabular induction electrodes 10 are bonded to the cooling surface of each cooling plate 11, 12 so that the heat from the tabular induction electrodes 10 is efficiently dissipated through the cooling plates. See Iwanaga at Column 3, lines 10-63.

Combining the cooling plates in the stepped ozonizer of Iwanaga with the ozone generators of Suzuki and Hammer would not result in the present invention. None of the references cited teach or suggest alone or in combination a structural carrier non-thermal plasma reactor element constructed from one or a combination of null, single, and double dielectric barrier structural carriers as presently disclosed and claimed.

Distinctions Over Suzuki in view of Hammer and further in view of Rau

Rau discloses a device for generating ozone from oxygen-containing gases by a silent discharge and includes an arrangement with at least one gap through which the gas flows. The arrangement includes an electrode and a dielectric that separates the gap from another electrode. The gap is filled up with an electrically and thermally conductive gas-permeable arrangement that is in electrical and thermal contact with the adjacent electrode and that the oxygen-containing gas flows through. The gas-permeable arrangement includes a multiplicity of discharge spaces wherein the oxygen-containing gas is exposed to a high field strength and converted into ozone, and the reaction heat occurring in the gap is dissipated to the adjacent electrode by the electrically and thermally conductive gas-permeable arrangement.

As discussed with reference to Suzuki, etc., above, Rau does not teach or suggest the structural carrier and separation of previously combined function as presently disclosed and claimed. Doping a dielectric material does not result in the present invention. As Rau notes in Column 1, lines 40-46, high grade ceramic materials in the form of formed bodies with high dimensional stability are extremely expensive while thinner dielectrics increase the risk of dielectric puncture. This is one of the problems that the present invention overcomes with the separation of function arrangement of structural carrier for support function and high k barrier layer for dielectric function. Combining a doped dielectric material with the ozone generators of Suzuki and Hammer would not result in the present invention.

Based upon the remarks presented herein, it is submitted that the Examiner's outstanding rejections have been overcome. As a result, Applicants respectfully request that a timely Notice of Allowance be issued in this case.

Should the Examiner have any questions regarding this matter, the Examiner is requested to contact Mr. Jimmy L. Funke, who may be reached in the Troy, Michigan area at (248) 813-1214.

If there are any additional charges with respect to this Response or otherwise, please charge them to Deposit Account No. 50-0831 maintained by Applicants' attorney.

Respectfully submitted,
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